Evidence for Prehistoric Dryland Farming in Mainland Southeast Asia: Results of Regional Survey in Lopburi Province, Thailand

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IN MANY AREAS OF THE WORLD with historically described agricultural systems, archaeologists have frequently assumed that the parameters of these systems can be projected into the preliterate past. Models for past agricultural regimes may be drawn from ethnohistoric accounts, ethnographic studies of traditional cultivation practices, or observations of major crops currently grown in the region. Although these are frequently sources of insight into the structure of subsistence economies, exclusive reliance on modern systems as a source of hypotheses may limit understanding of the nature of prehistoric agricultural systems. Furthermore, these limited constructions can generate assumptions that prevent archaeologists from recognizing patterns that do not conform to expectations generated from these models.

For example, European settlers in seventeenth-century eastern North America found native communities engaged in cultivation of maize, beans, and squash (Hudson 1976; Swanton 1946). It was widely thought by archaeologists that these cultigens, along with the concept of cultivation, were adopted by hunting and gathering groups from agricultural societies to the south and west, even though cultigen remains had been recovered from contexts dating to c. 2500 B.C. in eastern North America. Cucurbit remains exhibiting characteristics consistent with genetic manipulation were found in the Phillips Spring Site in Missouri and predate any other recovered domesticated seed plants (Smith 1992*a*). It was, however, generally concluded that "the eastern horticultural complex was not an independent development, but was a regional adaptation of the concept of horticulture that originated in Mesoamerica" (Chomko and Crawford 1978:405). This conclusion "deflected research interest over the past decade away from a consideration of the developmental process leading to the cultivation and domestication of local crop plants. The early appearance of an apparently tropical domesticate led to the apparently prevalent opinion that plant husbandry was introduced into eastern North America from Mexico ..." (Smith 1992*a*:39). Attribution of the origin of domesticated cucurbits to Mesoamerica was influ-

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enced by knowledge of historically documented cultivation systems and led to conclusions that influenced the course of fieldwork in eastern North America.

Recently, however, ethnobotanic research has shown that beans and maize introduced from Mesoamerica were incorporated into an existing vigorous agricultural tradition which had flourished for millennia prior to the introduction of these cultivars. Besides cucurbits, a sequence of indigenous cultigens has been identified which includes sunflower, goosefoot, and sumpweed (Smith 1992*b*). These crops apparently were replaced in importance by the higher-yielding beans and maize after A.D. 1150.

The identification of an agricultural system in existence in eastern North America before the introduction of Mesoamerican domesticates has altered archaeological perceptions of these prehistoric cultures and prompted new questions about the nature of domestication (Watson and Kennedy 1991). Clearly, reliance on ethnohistoric accounts of cultivation systems at the time of contact as the sole source of models yields an inaccurate view of the development of this prehistoric agricultural system.

In a parallel example from East Asia, it has been assumed that there was little or no plant cultivation in Japan prior to the introduction of wet rice. Furthermore, these assumptions had a direct impact on the methods of archaeological research in Japan. Crawford notes that "(f)lotation is rarely conducted in Japan outside of Hokkaido today. It appears that influential local archaeologists have made their own conclusions about plant food subsistence and see no need to test what is self-evident" (Crawford 1992 : 18). Archaeological investigations on Hokkaido have shown, however, that cultivation was an important component of the prehistoric Ainu economy. A number of cultigens were grown, including millets, barley, beans, and melons (Crawford 1992). In southern Japan, these cultigens decreased in importance after the introduction of wet rice in the first millennium B.C.

Assumptions about the primacy of rice have also structured inquiries into the prehistory of interior Mainland Southeast Asia. Wet rice was undoubtedly the mainstay of Mainland Southeast Asian populations throughout the span of written records. Chinese commentary on agriculture in the Mekong Delta in the third century A.D. records that "[the inhabitants of the region] engage in farming. They sow [or plant] in one year and reap for three" (Wheatley 1983 : 79). Wheatley argues that the phrasing of the original text refers to a grain rather than to sago, sugarcane, or root crops. This grain may have been rice. Fan Cho, an officer in the Chinese military detachment to Tongking in the ninth century A.D., observed wet rice being grown in valley bottoms in Yunnan (Wheatley 1983 : 65). An inscription from thirteenth-century A.D. Sukhothai lists maintenance of padi fields as one of the accomplishments of King Ramkhamhaeng (Wyatt 1982 : 54). In 1687, de La Loubère (1969 : 17), a French envoy to the Kingdom of Siam, found that "rice is the principal harvest of the Siamese and their best nourishment." He described wet transplanted rice in the neighborhood of Ayutthaya.

Given this rich historical record documenting the cultivation of wet rice, it has generally been assumed that this crop was also of great importance in interior regions of Southeast Asia prior to written records. The domestication of rice is an important element in Gorman's (1977) model for the transition from a foraging to an agricultural economy.

Models of the development of cultural complexity in mainland Southeast Asia argue for a close relationship between the appearance of iron technology, water buffalo, wet-rice cultivation, and complex chiefdoms. Specifically, these models posit that iron plowshares and water buffalo were necessary to turn heavy clay soils and make large-scale wet-rice irrigation feasible. With the adoption of an agricultural regime that could support large populations and generate surplus, expanding populations soon began to develop large ditched or moated settlements organized into chiefdoms (Higham 1989*b*). Yet, as Glover (1985 : 269) notes, "archaeological evidence of early rice is not good, and many of the claims are not always supported by detailed evidence, either of context, association, or morphology of the samples." No criteria have been developed to distinguish between wet and dry rice-grain morphology, and identification of domestic rice has derived primarily from cultural context rather than plant characteristics (Yen 1995 : pers. comm.).

The archaeological evidence for prehistoric cultivation of rice in Southeast Asia is sparse and has been reviewed by Glover (1985). The earliest evidence for rice cultivation comes not from Southeast Asia, but from the site of Pengtoushan, in Hunan Province, China (Yan 1991). The site is on the northern margins of Dongting Lake, in the middle Yangtse River Valley. This open-air site, dating to 8500–7800 B.P., has yielded evidence of houses built directly on the ground rather than on stilts. Rice husks were found in pottery and in fired earth. No wood was preserved and no agricultural implements were recovered. The excavators have suggested that the rice remains are of a domesticated variety, based on the size of the grains (Yan 1991 : 121).

Yan (1991) argues that rice was probably domesticated in the middle and lower Yangtse Valley, as over 80 prehistoric sites with rice remains have been located in this region. He points out that no domesticated rice has been found in sites in far southern China dated before 3000 B.C. The majority of the investigated settlements are caves, and may have been special-function sites in a more diversified settlement system. Thus, there is no evidence for rice cultivation in far southern China before the beginning of the third millennium B.C.

The earliest occurrences of domestic rice in Mainland Southeast Asia date to the same time period. Most of the data concerning rice in the interior regions come from excavations in Northeast Thailand. Plant remains, identified as rice chaff (Bayard 1977), were found in pottery from the earliest occupation levels at Non Nok Tha, the Phu Wiang I phase, dated to 3000 B.C. Yen (1982 : 63) describes the rice as genetically intermediate between a wild and a weed species. Rice was also found in early levels at Ban Chiang, but could not be identified to a species level (Yen 1982). Cultivated rice was recovered from Ban Na Di, whose earliest levels are dated to 1500 B.C. (Chang and Loresto 1984 : 384).

On the Central Plain of Thailand, circumstantial evidence for cultivation comes from the site of Kok Phanom Di. The excavators argue that although the site is dated to 2000–1500 B.C, there was occupation in the area at an earlier time. Their evidence for cultivation consists of two peaks in the amount of charcoal present in pollen profiles. These peaks are dated to between 5870 and 4515 B.C. (Maloney et al. 1989 : 368). They were correlated with a rise in pollen from grass species and species known today to be rice-field weeds. Maloney et al. (1989) suggest that the charcoal in the profiles resulted from burning to promote growth of grasses, possibly rice.

Although excavations in Thailand have indeed yielded rice grains, the status of the species as a cultivar, the methods of cultivation, and the importance of rice in the subsistence economy throughout the prehistoric sequence remain largely unelucidated. Despite this lack of unequivocal evidence for rice in the early prehistoric subsistence economy, survey projects in Thailand have, nonetheless, been designed to identify sites supported by a wet-rice economy. This is accomplished in two ways. First, survey efforts were concentrated in ecological zones suitable for growing wet rice. Second, the major survey methods used were aerial photograph reconnaissance and informant interviews. Though these survey methods elicit much information with a minimum of effort, they do not produce representative regional samples of sites. Specifically, these methods target large sites and mounded sites in regions currently associated with rice cultivation. This research strategy hinders the recognition of other agricultural systems that may have preceded or existed contemporaneously with wet-rice cultivation. Such failures to recognize archaeological bias can also lead to erroneous conclusions about the development of agricultural systems in the region.

Most of the major published surveys that have provided the basis for our understanding of the prehistoric sequence in the interior of Mainland Southeast Asia were conducted in Northeast Thailand (see Fig. 1). The Kumphawapi Survey was designed to examine the settlement system that included Ban Chiang. The purpose of the Lake Kumphawapi survey was to "enlarge our understanding of the so-called 'Ban Chiang' culture" (Kijngam et al. 1980 : 1). "While a handful of the inhumation burial sites have been excavated, there has been no concentrated settlement pattern survey of these small (c. 0.6–5.2 ha) burial and settlement sites relative to the paleoenvironment" (Kijngam et al. 1980 : 57). Although not specifically stated, accompanying figures indicate that the survey universe is about 965 km^2.

The survey methods involved the use of aerial photographs as well as informant interviews. Aerial photographs of the region were examined with a stereoscope for the presence of possible mounds, which were then examined on the ground. All villages in the survey area were visited and the local inhabitants asked for information about sites. "It is strongly felt ... that the most profitable way of site recovery in NE Thailand is to solicit information from the local inhabitants" (Kijngam et al. 1980 : 10). A total of 30 prehistoric sites were recovered in the course of this research, giving an average site density of .03 sites/km^2 (Table 1). Of these, 23 (76 percent) were mounded. The remaining sites were not classified.

This study has been criticized on other grounds (Wilen 1987*b*) that are not germane to this discussion. There are, however, several additional points to be made. One is that the survey methods used were biased in favor of mounded sites through their emphasis on the use of aerial photographs and interviews with informants. As mounded sites are usually the product of relatively dense habitation of some duration, we may expect that the economy of these sites, at least in the later periods of occupation, was centered on agriculture, probably rice cultivation. Although the initial settlement may not have been prompted by accessibility to rice-producing soils, the locations of these settlements near land suitable for cultivating rice insured their continued use as rice agriculture became more important. Second, the modern villages are also involved in rice agriculture, and these settlement locations can be expected to be equally influenced by aspects of their econ-

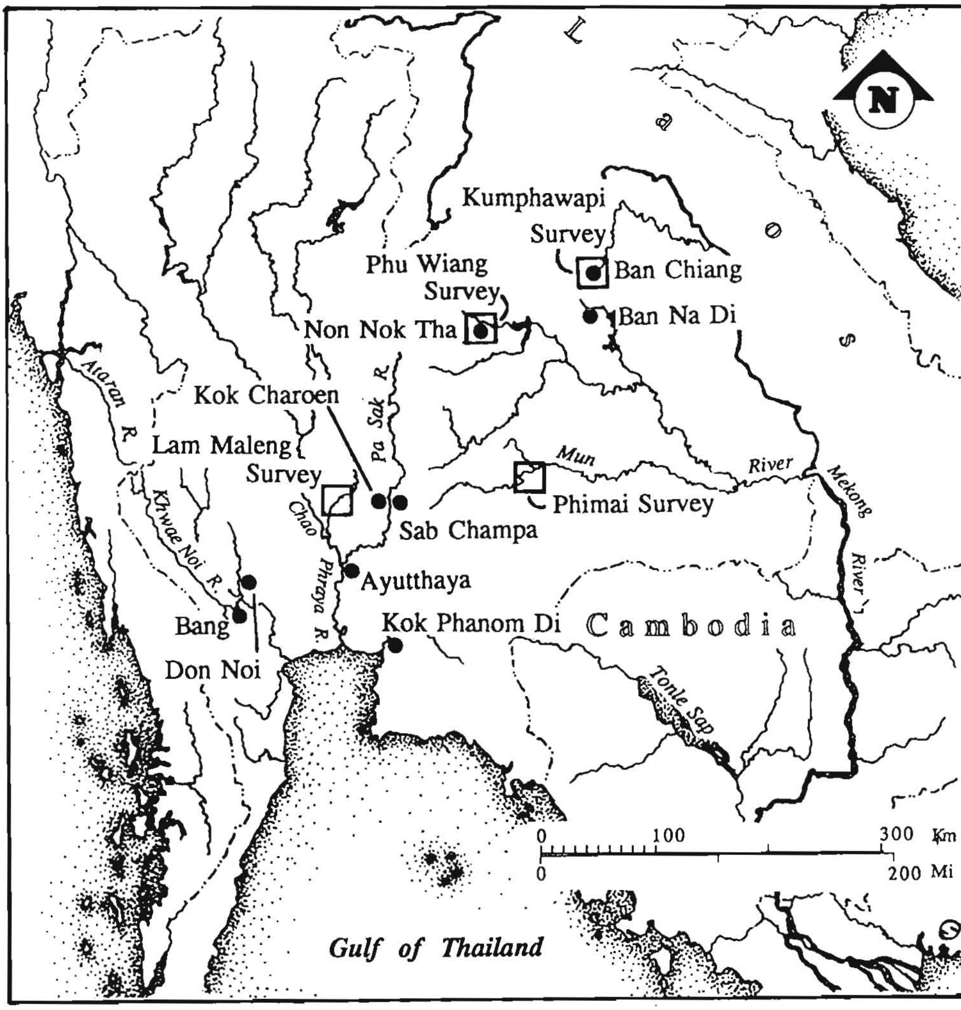

Fig. 1. Location of major settlement surveys in Mainland Southeast Asia.

omy. Therefore interviews with rice cultivators would probably direct one to sites with which they are most likely to be familiar, sites near rice fields. Thus, these survey methods may have selectively identified sites whose locations reflected their commitment to rice agriculture and therefore did not represent a "regional settlement pattern," although that was the research objective. Little wonder that the results of catchment analysis indicate that the inhabitants of the sites were growing rice. It is an assumption implicitly built into the survey methods.

A second study considered here is a survey conducted in the Phu Wiang area, near Non Nok Tha (see Fig. 1). The purpose of the project was to place the data recovered from excavations in the area into a regional context (Wilen 1987*a*: 287), which implies, at least, the recovery of a settlement pattern. The area of the research universe is never given, but it appears to be about 750 km^2 (Wilen 1987*a*: 303, fig. 50).

TABLE 1. SURVEY PROJECTS IN SOUTHEAST ASIA; METHODOLOGY AND RESULTS

	VILLAGER	AERIAL	SYSTEMATIC	AREA	DENSITY	
SURVEY PROJECT	INTERVIEW	PHOTOS	SURVEY	SURVEYED	SITES	(/km^2)
Loei (Penny 1986)	Yes	No	No	1100	45	0.04
Khorat (Higham and Kijngam 1984)	Yes	Yes	No	965	30	0.03
Khorat (Wilen 1987)	Yes	Yes	Yes(?)	750	24	0.03
Phimai (Welch and MacNeil 1990)	Yes	Yes	Yes	700	82	0.11
Bais (MacDonald 1982)	No	Yes	Yes	16	22[a]	1.37
Lam Maleng (Mudar 1990)	Yes	No	Yes	60	105[b]	1.68

[a] Aguilar and Lombendina Phase sites only
[b] Prehistoric sites only

Wilen states that three methods of site survey were used: surface survey, informant survey, and aerial photograph interpretation. He notes that "in many of the studies conducted in Southeast Asia to date there has been little or no discussion of the impact of the methods utilized" (Wilen 1987*a*: 288). In this study, local inhabitant interview was utilized as the primary means of locating sites. All 55 of the extant villages in the watershed were visited during the course of the survey. Some survey made on foot was also conducted, but we are not told what percentage of the research area was, in fact, covered.

The survey located 24 sites, an average density of .03 sites/km^2 (Table 1). Nineteen of these, 78 percent, were either mounded or under present villages. Wilen indicates that the survey located nearly all of the more substantive sites in the watershed of the survey area. After analysis, he concluded that the locations of these sites were well suited to rice agriculture. Again, this might be expected, as villagers would be most familiar with sites close to their area of work. Wilen goes on to note that these sites cannot be dated at the present time, beyond recognizing that they are prehistoric. He suggests that the settlement pattern he identified probably represents a settlement system that was functioning late in the prehistoric sequence (500 B.C.–A.D. 0) (Wilen 1987*a*: 366).

The area encompassed by the Phimai Project survey is situated in the southern part of the Khorat Plateau, in the Mun River Valley (see Fig. 1). Welch and McNeill conducted a low-intensity survey in 1989 in the vicinity of the Angkorian regional capital of Phimai as part of a larger project to elucidate cultural development in this region. The purpose of the study was to "examine the variability in site size, site density, patterns of distribution, and periods of occupation of sites among each of the major regional environmental zones" (Welch and McNeill 1991: 210). They examined 270 km^2 of alluvial plain, 130 km^2 of low terrace lands, and 300 km^2 of upland, for a total of 700 km^2.

The survey methods used consisted primarily of aerial photograph interpretation and informant interviews. Ground reconnaissance was conducted in several areas. The investigators estimate that 80–90 percent of the total number of habitation sites were identified in the survey area using these methods. A total of 82 habitation sites were recorded during the 1989 field season, yielding an average site density of .11 sites/km^2 (Table 1).

This study is notable in that there was explicit inclusion of environments that were not primarily suited for rice growing in the survey. The investigators found 27 sites in upland areas, which were primarily dated to later periods (Welch and McNeill 1991 : 214). They propose that these sites were situated to exploit special resources of the upland areas, such as laterite and salt. As in the previous surveys, however, primary survey methods consisted of aerial photograph reconnaissance and informant interviews.

The surveys examined here have emphasized use of aerial photograph reconnaissance and informant interviews as the primary means of locating sites. With the exception of the Phimai Project, survey efforts were directed toward investigation of ecological zones appropriate for growing wet rice. The data collected through these surveys consist primarily of mounded sites of a late time period located in areas with potential for wet-rice agriculture. Reconstructions of the prehistoric sequence, which assume that these are representative samples, posit that the earliest habitation in Northeast Thailand was based on a mixed foraging-farming economy (Higham 1989*a*: 130–131), and that rice, probably some form of wet swidden, was utilized.

Ethnobotanical research in East Asia suggests that cereal grains such as millets and barley were domesticated by 8000 B.P. and formed the basis for agricultural systems there prior to the introduction of wet rice. The millets, in particular, are adapted to low rainfall environments and were cultivated on the Loess Plateau in northern China (Crawford 1992 : 23). It would have been feasible to grow millets, dry rice, and other dryland crops in Southeast Asia as well. Archaeological research in Southeast Asia, however, has focused primarily on the recovery of settlement systems involved in wet-rice agriculture. It has not been feasible to explore the possibility that other agricultural systems existed prior to, or in tandem with, those systems centered on rice agriculture with the research strategies examined here. Given this, it is not possible to examine the factors involved in a transition from one agricultural system to another with these methods.

Regional survey is, nonetheless, one of the best ways to approach questions about settlement systems (Fish and Kowalewski 1989). In the absence of ethnobotanical data, it provides information about land use, from which agricultural practices may be inferred. These inferences may then be confirmed or rejected through a program of excavation. It also provides a representative sample of sites for locational analysis.

The purpose of this paper is to discuss the results of the Lam Maleng survey within the context of dryland agricultural systems. In 1989–1990, a settlement survey was conducted in the Lam Maleng Valley, on the eastern margins of the Central Plain, in Lopburi Province, Thailand. Although an incomplete regional survey, this effort examined both middle and upper terraces within the watershed of the Lam Maleng Stream. The survey method consisted of intensive pedestrian reconnaissance. This method located over 100 prehistoric sites in 60 km^2, yielding a site density of 1.68 sites/km^2. None of these sites was mounded. This figure contrasts sharply with the site densities of the surveys discussed above, but compares well with another Southeast Asian survey that utilized 100 percent coverage of selected areas, the Bais Project in Negros Oriental, Philippines (Hutterer and Macdonald 1979, 1982) (Table 1).

The survey methods of the Bais Project were designed to identify a statistically representative sample of sites that could be used to construct settlement patterns, from which inferences could be drawn about the nature of cultural development in the lowland Philippines. A stratified random sampling strategy recovered sites from all major ecological zones in the Tanjay River Basin. Overall, this survey method identified an average 1.37 sites/km^2.

The Lam Maleng survey resulted in the recovery of 159 sites. Using locational analysis, this study tests the hypothesis that wet-rice cultivation was practiced, using a sample of sites ranging in date from ca. 2500 B.C. to the tenth century A.D.

ENVIRONMENTAL BACKGROUND

Climate

The climate of central Thailand is dominated by the southwest and northeast monsoons. From mid-May to mid-October, the southwest monsoon brings warm, wet air up from the Indian Ocean. August and September are generally the wettest months of the year, but flooding usually occurs in October (Kaida 1976 : 173). From November to February, the northeast monsoon prevails. The weather is cool and dry as the air moves over the Asian land mass from Siberia. From November to April, dry and increasingly hot conditions prevail, cooling somewhat after the southwest monsoon begins. Intermittent rains begin in May and increase through August. The rainfall pattern is strongly seasonal, with the majority of precipitation occurring between May and October.

Within the Central Plain, some variation in rainfall exists as one moves from east to west (Kaida and Surarerks 1984 : 233–235). The Bangkok Plain and eastern Marginal Plains receive the most rain. The mean average yearly rainfall is 120 cm. This climatic regime is defined as a tropical monsoon climate, with a 5.5–6.5-month rainy season of low rainfall (Kaida and Surarerks 1984).

Despite relatively high average annual rainfall, the threat of drought is ever present. Inner Thailand is the driest area in Southeast Asia, accounting for the presence of grumosols on the eastern side of the Upper Plain (Kyuma, in Yoshino 1980 : 63). Maruyama estimates that drought conditions occur, on average, one year in four on the Central Plain (Maruyama 1976 : 159). Drought usually occurs in the early rainy season, May through July (Rasmidatta 1976 : 150). This may postpone or even prevent the planting of crops.

Topography and Soils

The research area encompasses the Lam Maleng Valley, whose stream drains a fan-terrace complex in the Upper Bangkok Plain, on the eastern margin of the Central Valley (Fig. 2). The Lam Maleng Stream currently runs southwest and enters the Chainat–Pasak Canal at Ban Mi; formerly it joined the Lopburi River between Singhburi and Lopburi. This stream and its tributaries drain an area of inselbergs on the southeast, and a broad, gently sloping tableland on the northwest.

This fan-terrace complex runs parallel to the Chao Phraya Valley through

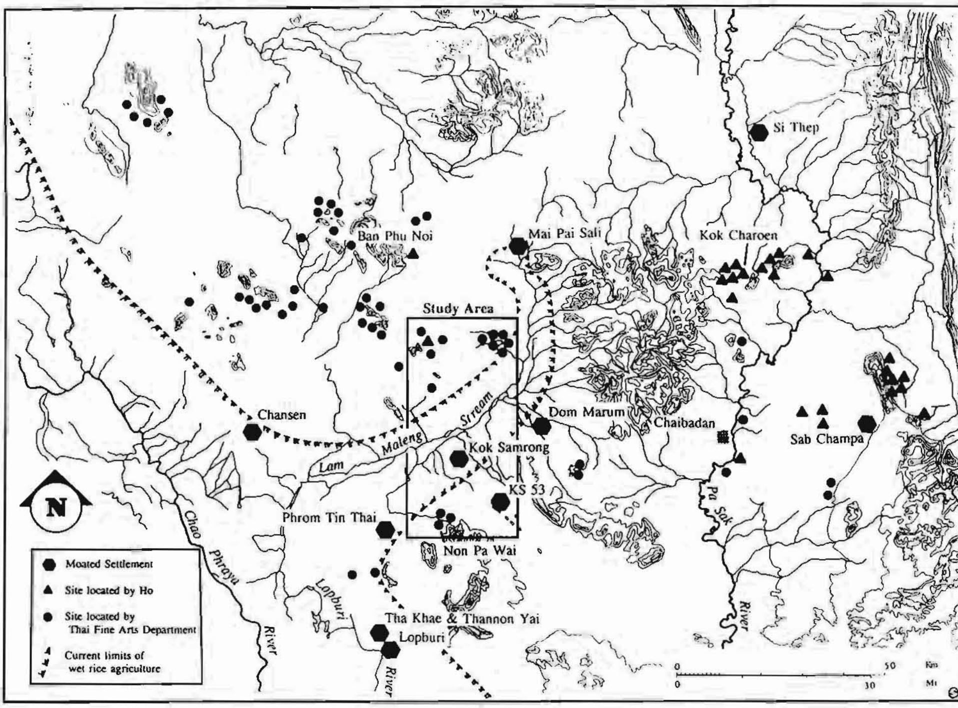

Fig. 2. Regional map of eastern Bangkok Plain.

three provinces, Nakhon Sawan, Lopburi, and Saraburi, and is known as the Lopburi Grumosol Area (Takaya 1987 : 98). Fan-terrace soils are usually alluvial, lateritic, and of low fertility. In contrast, the Lopburi Grumosol soils are nonlateritic and fairly fertile. These differences stem from the geomorphological history of the region. Lopburi Grumosol soils developed in situ during the Middle Pleistocene from an underlying limestone formation. They derive from the weathering of the Saraburi Group, which rings the western edge of the Khorat Plateau as a result of the relatively arid Pleistocene–Holocene climate (Nutalaya et al. 1984 : 155).

In the survey region, the Lopburi Grumosol can be divided into two formations depending on elevations. Present land-use practices are correlated with a pattern of grumosols found on middle elevations in the Lam Maleng valley bottom and rendzinas at higher elevations on the high terraces. The lower-elevation soils are heavier grumosols and include the Pak Chong, Tha Rua, and Wathana Series. Water retention of these soils is adequate for wet rice. One major crop of nonirrigated rain-fed transplanted rice is grown on the alluvial plain in the Lam Maleng Valley per year (Fukai 1976 : 152).

At upper elevations, rendzina soils include the Takhli, Pak Chong, and Lopburi High Phase Series. They are clay, clay-loam, or silty clay, and are poor in water retention qualities (Tunduan 1976 : 36–42). The fertile rendzina soils permit the cultivation of dry crops including maize, cotton, beans, sugarcane, and fruit trees. Millet is also an important crop (Oldeman and Frere 1982 : 96). The

Lopburi Grumosol is known as the "maize belt of Thailand" (Kaida and Surarerks 1984 : 248), as 80 percent of the country's maize is grown on this soil formation. These soils are not considered appropriate for wet-rice agriculture (Kawaguchi and Kyuma 1969 : 15).

The region is also studded with inselbergs, hills of volcanic uplift composed of granites, andesites, and limestone. These outcrops were prehistoric sources of raw materials for stone items and iron and copper ores.

The Lopburi Grumosol Area is distinctive in that, prior to clearing, the limestone-derived soils supported a denser primary forest vegetation than is typically found in areas marginal to the Chao Phraya Valley. Lateritic soils in these fan-terrace complexes usually support open-canopy forests, interspersed with large stands of grasses and bamboos, giving a savannah-like appearance (Pookajorn 1981). Accounts of the forest vegetation in the Lopburi Grumosol Area in the 1960s indicate that both high terraces and middle terraces were covered by closed-canopy forests. Takaya (1987 : 100) noted that there were tall trees with large buttress roots and that the crown canopy was "firmly closed with evergreens in the upper story" (1987 : 151). Original vegetation included *Ormosia, Hopea, Pterocarpus, Dipterocarpus, Bombax, Ceiba, Hibiscus,* and *Corchorus*, as well as bamboos.

The forests have been logged in the last 30 years, primarily for charcoal production. At present, remnant forests are confined to ridgetops and small patches on the high terraces. Isolated trees stand among rice fields as the only reminder of forests that once flourished on the middle terraces. The area also supported a diverse fauna that included tigers, elephants, wild pigs, deer, bear, porcupines, and several species of wild cattle. De La Loubère (1969 : 43) noted in 1687 that King Narai hunted "Tyger and Elephant" in the vicinity of Lopburi. Today, these species are largely confined to national parks, as deforestation has drastically affected the size and quality of the natural habitat.

SURVEY METHODS

Survey efforts focused on locating all sites within an irregularly bordered area cross-cutting the middle and high terraces of the Lam Maleng Valley. Because the high terraces had recently been cleared and devoted to agriculture, intensive pedestrian survey was judged to be the most effective method for collecting a representative sample. All open land within the designated areas was systematically examined for signs of occupation. When a site was identified, its location was recorded, the extent of the site was mapped, and a representative sample of pottery collected. Sites thought to represent more than one time period or larger than usual were sampled through a controlled-surface pickup sampling method.

Sites were defined as areas of artifact concentration. The definition of a site was more dependent on density of artifacts than on absolute number of sherds recovered or size of area containing sherds. Isolated sherds were not recorded, although isolated stone flakes and stone tools were recorded as spot finds. A number of low-density artifact clusters, tentatively identified as farmsteads or hamlets, were recorded, although it is doubtful that all were recognized.

The majority of the ground cover on the high terraces consisted either of plowed soil, young crops, or fields of recently harvested crops. As a consequence, ground visibility was quite high. In the valley bottom, the survey was conducted primarily in harvested padi fields. Initially, team members walked through the center of these fields. Later, this was judged to be of little utility, as the ground had not been plowed since harvesting and was covered with sediments deposited by receding rainwater. Subsequent efforts were directed toward the examination of retaining walls only.

Assessment of archaeological sites in rice fields is often hampered by activities associated with construction of retaining walls and irrigation channels. Barnes (1986) notes that, in archaeological investigations of padi fields in Japan, materials may be moved laterally and redeposited in the walls of the fields during padi construction. Other artifacts may be sealed beneath a hardpan, not to be disturbed until deep plowing brings them to the surface. Artifacts may be moved both laterally and vertically during the excavation and cleaning of drainage ditches and irrigation canals. Dredging activities may also deposit materials adjacent to water courses. Barnes found, however, that the most radical distortion of the archaeological record resulted from road and house-platform building activities. Materials could be moved as much as 0.5 km as part of fill for road grades.

Rice agriculture in the Lam Maleng Valley differs from the regime in Japan described by Barnes in several ways. First, fields are rainfall inundated rather than being stream irrigated. The accumulation of sediment load is expected to be lower and to bury artifacts only minimally. Second, alteration of the landscape in the study area for agricultural purposes is less extensive than in Japan. It is mainly limited to drainage ditches rather than an elaborate set of irrigation and feeder canals. There also does not appear to have been massive earth-moving activities for the construction of padi fields. Padi fields constructed by machinery were encountered during the survey and could be recognized by the greater size of the retaining walls thus produced. Hand-constructed retaining walls were generally low, less than 0.5 m in height, whereas machine-made retaining walls were higher.

A key factor in the degree of lateral displacement of artifacts and distortion of site area is the size of padi fields. I have little data on this topic, but my impression is that individual fields are relatively small. Fukai notes that the average landholding in the area in the 1970s was 3–4 ha, and individual fields would have been smaller. Therefore, in computing areas of sites found in rice fields I have made no adjustments, either by increase or decrease. I suggest that lateral displacement of artifacts used to determine site limits has affected these approximations of site size only minimally.

A sample of artifacts was recovered from all sites encountered. Artifact classes included pottery, metal-working debris, bracelets and bracelet cores, and chipped and ground stone. Sites were dated through analysis of associated pottery. A preliminary regional prehistoric ceramic chronology was constructed, relying on seriated survey results (Mudar 1993) and excavated samples from the sites of Non Pa Wai (Rispoli 1990) and Tha Khae (Rispoli 1992). This chronology employed rim profiles, decorative motifs, and, to a lesser extent, fabric inclusions, to date sites. Protohistoric and Early Historic (Dvaravati) sites were dated using the ceramic sequence from Chansen (Bronson 1976).

RESULTS

A total of 60 km^2 was surveyed, consisting of an irregularly bounded transect running from north to south and east–west extensions parallel to streams and ridgetops (see Fig. 3). Within this boundary, over 90 percent of the land was carefully examined, excluding areas under habitation. Thirty-seven percent of the surveyed land included middle terraces; the rest consisted of high terraces.

The survey recorded a total of 159 sites. Of this total, 105 are considered to be prehistoric in age, 10 are protohistoric, 31 are Dvaravati, 4 are Khmer-Sukhothai, and 9 are Ayutthaya-Rattinakhosin (Mudar 1993). The long prehistoric sequence was divided into Early, Middle, and Late periods.

Early Period Prehistoric Sites: 2500–1500 B.C.

Early Period sites are contemporary with the Phase I occupation at Non Pa Wai (KS 25), a prehistoric site located in the southwestern corner of the study area and excavated by a joint University of Pennsylvania–Thai Fine Arts Department team (Pigott and Natapintu 1988, 1990). The pottery from this phase of occupation is characterized by large jars whose tall necks are colored with a bright-red slip. Decoration motifs include fields of incised geometric curving designs, whose interiors are filled with dentate stamping (Rispoli 1992). Coarse basket impressions on large jars are also characteristic of this time period. Excavated samples are known primarily from burial contexts at Non Pa Wai (KS 25) (Rispoli 1990) and at Sab Champa (Mayurie 1982), in the Pasak River Valley. Examples of zoned incised decoration are also known from the Bang site in Kanchanaburi (Sorensen and Hatting 1967), Early Period Ban Chiang (White 1992: pers. comm.), and the Phu Wiang Phase of Non Nok Tha (Bayard 1977).

A total of 20 sites were found that contained Early Period occupations (Fig. 3; Appendix 1), in addition to the previously investigated Non Pa Wai. Early Period sites were found primarily on the high terraces to the north and south of the valley bottom. Only three sites were found on the middle terraces. Site sizes range from 6.3 to .33 ha.

Middle Period Sites: 1500–1000 B.C.

Middle Period sites were identified by the presence of "hole-mouthed" jars, characteristic rim profiles, and a high incidence of heavy red slip on exterior surfaces (Mudar 1993; Rispoli 1990, 1992). Small pedestaled bowls with incised geometric designs are also dated to this period. These bowls were found in burial contexts at Kok Charoen in the Pasak River Valley (Ho 1984; Type 4). Other than the patterns of incising on these small bowls, there are no motifs which, at this time, can be securely associated with this phase of occupation.

The Middle Prehistoric Period is correlated with the appearance of a new metal-working technology. Reoccupation of Non Pa Wai dates to the latter half of the Middle Period, and excavations in the Phase II layers retrieved copper slag, crucible fragments, and ingot molds suggesting industrial smelting of copper. Besides the appearance of two other copper-smelting sites, Non Mak La and Nil Kham Haeng, in the immediate vicinity of Non Pa Wai (Pigott and Natapintu 1991), evidence of copper smelting was also seen at Ban Phu Noi, to the immedi-

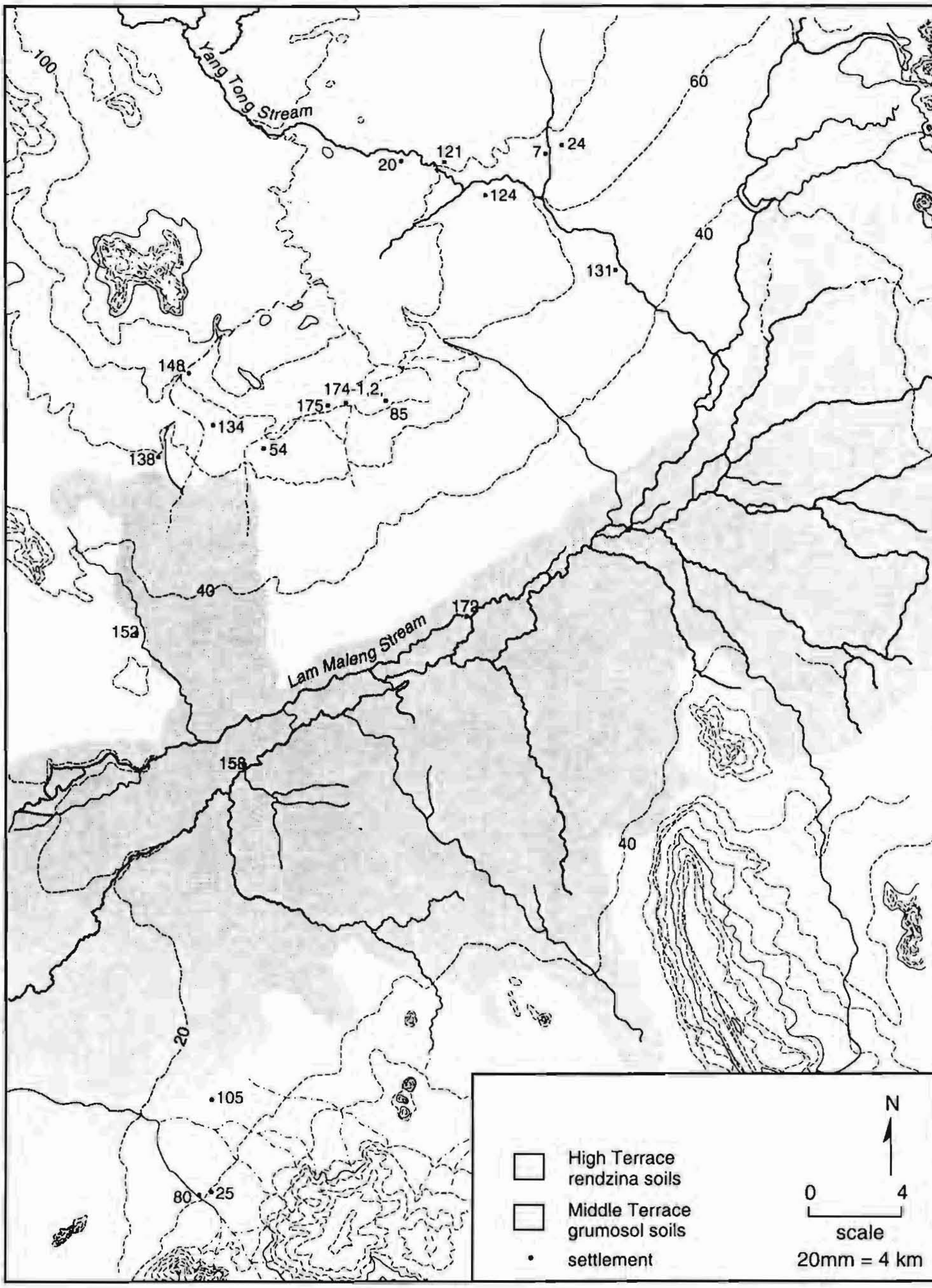

Fig. 3. Lam Maleng Survey: Early Prehistoric Period sites.

ate west of the study area (Natapintu 1987), and at Tha Khae, to the south (Ciarla 1992). No other copper-smelting sites were located during the survey.

A total of 49 Middle Period sites were identified from the survey, representing collectively 180 ha of habitation (Fig. 4; Appendix 1). Five sites are larger than

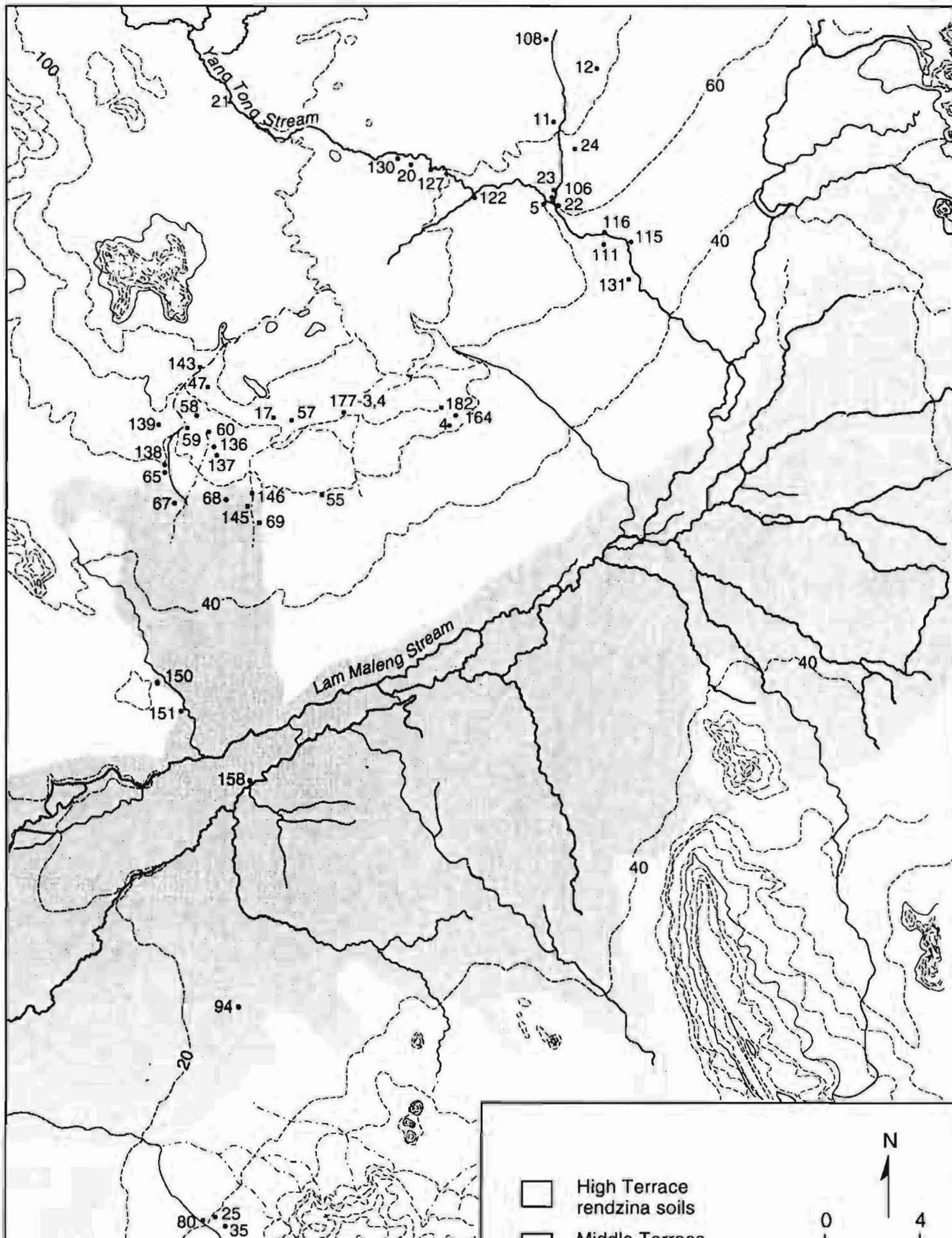

Fig. 4. Lam Maleng Survey: Middle Prehistoric Period sites.

10 ha, and the largest is 20 ha in size. Four of the five largest sites, KS 45, KS 150-1, KS 57, and KS 4, were investigated through systematic surface-collection techniques, as these sites were occupied during both Middle and Late periods. This approach provided more detail than simple paced transects and allowed the examination of variation in occupation through time within each site. Results of systematic surface collection indicate that all sites examined were first occupied and grew to their maximum size during the Middle Period and maintained this population level through the Late Period. Middle Period sites are distributed primarily on the high terraces; there were only four sites identified in the valley bottom.

A number of Middle Period sites in the survey may have been involved in a geographically restricted craft activity. Exhausted cores and utilized flakes were recovered from 12 sites on the high terrace in the northern portion of the survey. The sources of the raw material are unknown and probably not local. They consist of crypto-crystalline materials, cherts of various colors, jasper, and a small amount of quartz or quartzite (Shoocondej 1990 : pers. comm.). Cortex is present on much of the chert and may indicate collection of nodules from the ground surface. No local sources of these raw materials have been located, although several outcrops have been identified from Kanchanaburi, on the western side of the Central Plain (Bronson and Natapintu 1988).

Associations between Middle Period sites and stone-working debris in the survey area suggest that this industry is not the result of an earlier, aceramic occupation. Bronson and Natapintu (1988) have identified a similar industry from a site on the western side of the Bangkok Plain. At Don Noi, about 60 km north of the Bang Site, low-fired earthenware pottery was found in association with flaked adzes, utilized flakes, core fragments, and at least one finely flaked endscraper. The site is at least five hectares in size.

The tools from Don Noi showed signs of utilization and were not thought to have been pre-forms for ground-stone tools. A number of the tools showed silica gloss on the working edges, indicating use in cutting plant materials. The adzes showed gloss on the butt end as well. This suggested to Bronson and Natapintu (1988) that the tools were fitted into a wooden sleeve before use.

The raw materials for tools at Don Noi consist of a reddish-brown chert, a red-to-gray jasper, and a white-to-gray chalcedony. Almost no cortex fragments were found. The sources for the chipped stone assemblage were apparently local to the site of Don Noi.

A number of ceramic sites in Thailand are associated with a stone-working tradition, including other sites in Kanchanburi Province, a site in Loei Province, and several sites in south Thailand (Bronson and Natapintu 1988; Prishanchit 1988). It appears that, even after the appearance of metal and metal-working technology, stone tools were relied upon for the performance of subsistence activities.

Shell and stone bracelet fragments and manufacturing debris were also found at a number of sites dating to the Middle and Late Periods. One site (KS 17) is dated to the Middle Period; the rest (KS 4, 45, 57, 141, 150, and 158) have both Middle and Late Period components. All stone bracelets had "T-shaped" cross-sections. Several bracelets had been repaired with copper wire. Broken bracelets had holes bored through them for binding with copper wire. Stains were visible where the wire had been inserted to tie the pieces together. One site, KS 158, yielded bracelet cores, indicating that bracelets were manufactured at the site (see Ciarla 1992 for a discussion of manufacturing techniques).

Late Period Sites: 1000 B.C.–A.D. 1

Late Period sites have been identified by the presence of bowls with interior ledges on the lip of the profile, a distinctive ceramic paste, and decorative motifs consisting of incised triangles, frequently filled with parallel or cross-hatched lines, whose apexes pointed toward the base of the vessel (Mudar 1993). Excavated samples have been recovered from Non Mak La and Nil Khaem Haeng. The initial occupation at Chansen may also date to this time period; characteristic interior ledge-rim bowls were recovered from Phase I deposits (Bronson 1976).

The survey identified 41 sites that could be dated to the Late Period (Fig. 5; Appendix 1). As in the Middle Prehistoric Period, the largest sites were approximately 20 ha in size. The total occupation area consists of 141 ha, representing a small decrease both in number of sites and area of occupation.

The Late Prehistoric Period in the Lam Maleng Valley witnessed the appearance of iron smelting. A number of sites, dating to the Late Prehistoric Period or later, yielded iron slag but no metal tools.

The end of the prehistoric period is associated with site abandonment on the eastern Marginal Plains. Non Pa Wai was abandoned c. 700 B.C. and only sporadically reoccupied by small groups after this time. There appears to have been an abandonment event at some point in the prehistoric sequence at the moated site of Tha Khae and reoccupation during the Protohistoric Period. This is shown by a discontinuity in ceramic styles between Layers 2 and 3 (Ciarla 1992). Bronson (1976) also noted a ceramic discontinuity between Phases 1 and 2 in excavations at Chansen. He interprets this as indicative of site abandonment between the prehistoric and Protohistoric periods.

The Lam Maleng Valley may have also experienced population movement or abandonment during this time period. The majority of Middle Period sites in the sample were also occupied during the Late Prehistoric Period. In contrast, only 15 percent of the Late Period sites have Protohistoric occupations. Ciarla (1992) argues that this time saw extensive social reorganization, but the nature of this reorganization remains poorly understood, as both small sites in the survey region and sites that later become substantial settlements with moats and ramparts appear to have been abandoned during this time period.

Absolute dates for the termination of the prehistoric ceramic chronology are not currently available, as it has not been possible to obtain datable ceramic samples pertaining to this period from sites with continuous occupation from the Late Prehistoric through the Protohistoric Period. Excavations (Pigott and Natapintu 1991), however, indicate that there may have been fairly continuous habitation at Nil Kham Haeng from the late first millennium B.C. through the early first millennium A.D. A ceramic chronology that can be tied to an absolute dating sequence will be important in determining the dates of site abandonment in the survey region.

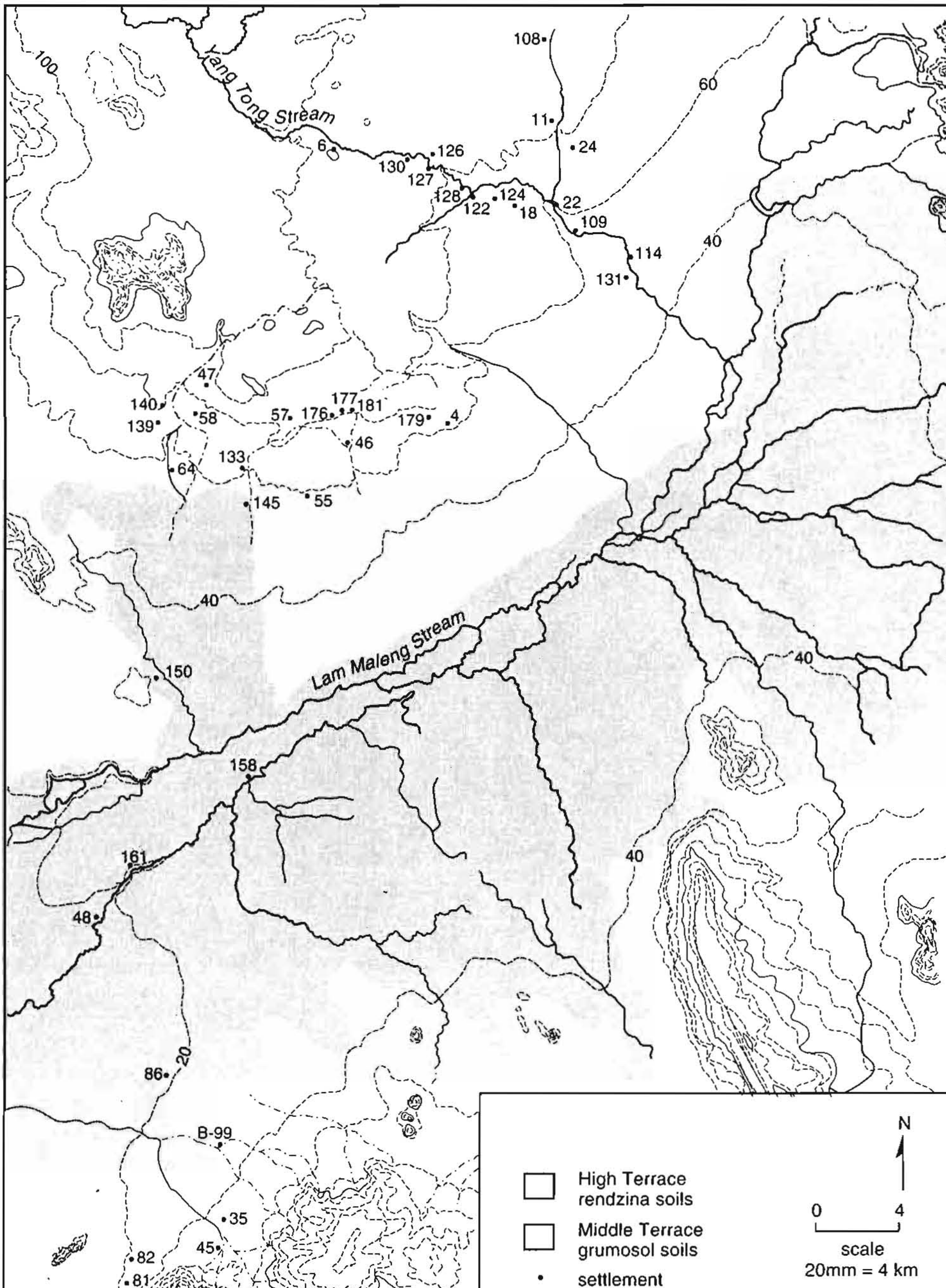

Fig. 5. Lam Maleng Survey: Late Prehistoric Period sites.

Protohistoric Period: A.D. 1–500

Accounts by early Chinese travelers dating to the Protohistoric Period record that a number of polities existed in maritime Mainland Southeast Asia, reaching from the lower Mekong to the lower Chao Phraya River (Wheatley 1983). These accounts indicate that one or more of these polities were located on the Central Plain. The geographical location and organization of these polities remains largely unelucidated, however. Artifacts from moated sites such as Chansen and U-Tong have parallels in artifacts from Oc Eo in the Mekong Delta, suggesting that extensive trade and communication networks were present in protohistoric Southeast Asia. On the eastern margins of the Central Plain, Chansen and Tha Khae contain protohistoric deposits.

Protohistoric sites in the Lam Maleng Valley were identified through recognition of characteristic pottery. A pottery typology for this time period was developed by Bronson (1976) for excavated samples from Chansen and is used here without modification. The ceramics from this period are distinctive in both shape and fabric. Bronson places the Protohistoric Period at A.D. 1 to 500. The beginning of the Dvaravati Kingdom, at c. A.D. 500, is signaled by changes in the ceramic assemblage.

A total of 19 sites were identified in the survey region, representing 74.5 ha of settlement (Fig. 6; Appendix 1). Sites range in size from less than one ha to ten ha, representing a decrease from the Late Prehistoric Period in largest site size. Compared to the previous periods, there also appears to be a greater tendency toward nucleation. Four of the sites are larger than seven ha in size and hold over half of the total settlement area. Three of these four sites are within 1 km of rice lands.

On the Central Plain the major occupations of the Early Historic Period can be differentiated from the Protohistoric Period by changes in the material culture and settlement patterns. These changes include the appearance of new portable art styles, pottery styles, and the appearance of moated settlements and monumental architecture in brick. Ciarla (1992), however, has found evidence to suggest that the site of Tha Khae was first moated during the Protohistoric Period rather than during the later Dvaravati Period. The appearance of moated sites during the Protohistoric Period might suggest that significant social and economic transformations began prior to the Early Historic Period.

Early Historic Period: A.D. 500–900

On the Central Plain, the Early Historic Dvaravati polity is generally thought to have constituted one of the first states in this region (Higham 1989*b*). The Dvaravati Kingdom is characterized by large moated towns—sometimes with ramparts, often with public architecture—situated on the margins of the Central Plain. Many of these sites would have had maritime access to the Bay of Bangkok, as the sea level was several meters higher 1500 years ago. Nakhon Pathom, the largest settlement, was probably the major capital.

Architectural and portable art shows evidence of contact with South Asia, as does the written language. The few recovered inscriptions are in a Sanskrit alphabet. The major religions, Buddhism and Saivism, also derived from South Asia. Despite this demonstrated contact, the degree of South Asian influence on the

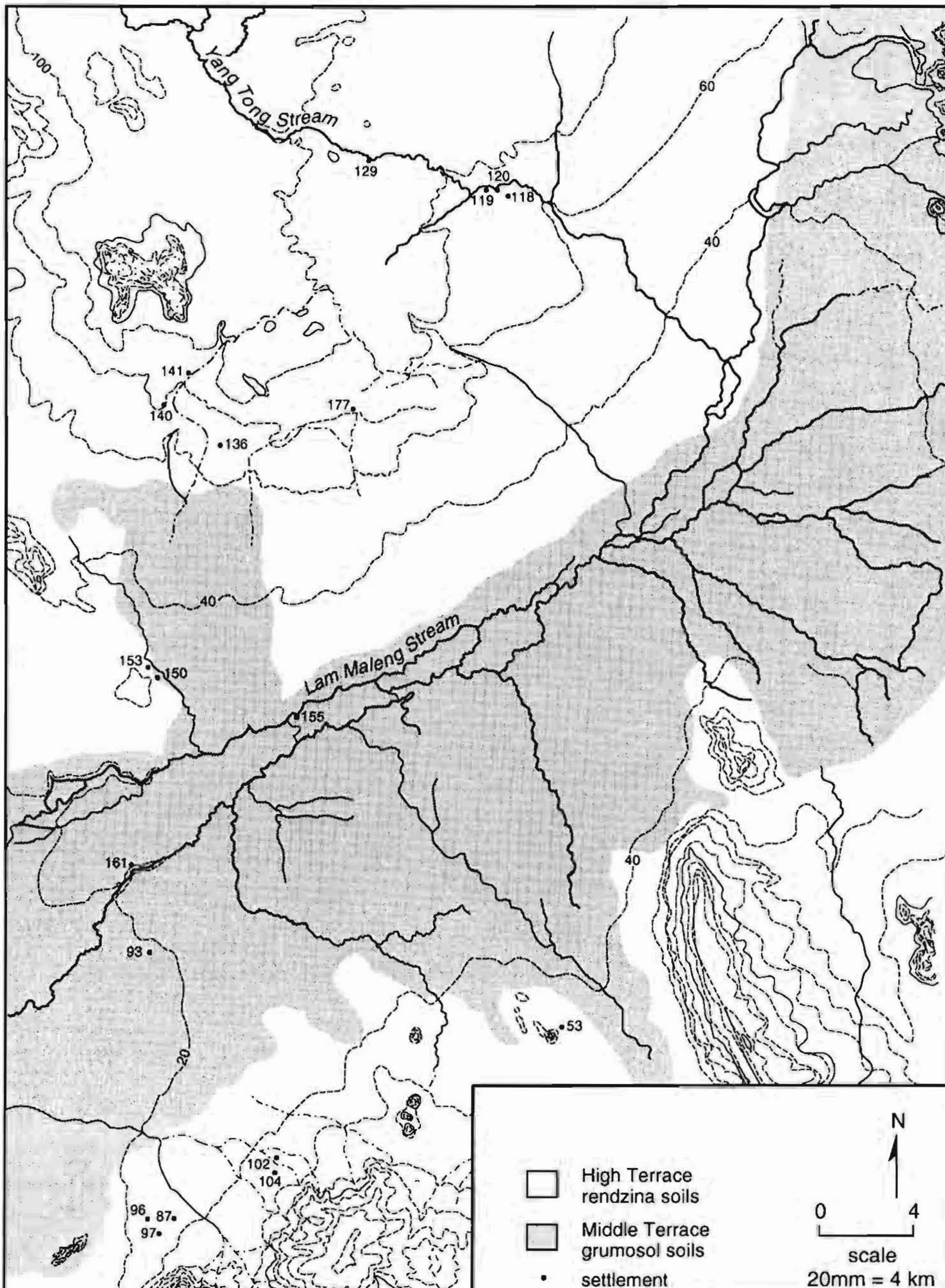

Fig. 6. Lam Maleng Survey: Protohistoric Period sites.

political and economic development of polities on the Central Plain is not fully understood.

Excavations in Early Historic sites have been primarily focused on public buildings in moated settlements (Bosselier 1968; Coedes 1928; Dupont 1959; Quaritch-Wales 1969). Two exceptions are Bronson's (1976) excavations at Chansen, a small moated settlement, and Suchitta's (1983) excavations at Ban Di Lung, a nonmoated iron-smelting site in Lopburi Province. These excavations indicate that there is widespread distribution of characteristic art styles and pottery, perhaps constituting evidence for regional integration. However, little evidence has been collected for intrasite spatial analysis of domestic deposits.

Textual evidence concerning the Dvaravati Kingdom is sparse. In A.D. 638 and again in A.D. 649, Dvaravati emissaries were sent to the Chinese court to negotiate trade relations. They carried ivory and "fire pearls" and requested horses in return (Krairiksh 1975:6). The Chinese record also noted that the Dvaravati Kingdom underwent a period of expansion and, after A.D. 647, had two dependencies, the island of T'an-ling and the kingdom of T'oyian, to the southeast of the Central Plain, possibly in Cambodia.

In the Lam Maleng Valley, a total of 25 Early Historic sites were identified through survey, all nonmoated (Fig. 7; Appendix 1). The sites located through survey efforts were primarily located on middle terraces. These Early Historic sites were undoubtably part of a larger settlement system, as at least nine moated settlements were located within 40 km of the Lam Maleng watershed (Fig. 2).

The results of this survey suggest a pattern of prehistoric habitation on rendzina soils and protohistoric and early historic habitation on grumosol soils. These patterns of settlement location are similar to those described in two other surveys in the Lopburi Grumosol region (Ho 1984; Thai Fine Arts Department 1988) (Fig. 3). The Thai Fine Arts Department conducted a survey in Nakhon Sawan and Lopburi Provinces, part of the "maize belt." This survey, conducted by Surapol Natapintu, located 78 archaeological sites, dating from c. 2500 B.C. to the first centuries A.D.

In 1983, Ho conducted a survey in the same area, concentrating on the region between Lopburi and Chaibadan. She located 30 sites, which she divided into three time periods. The Early Metal Age is approximately dated to 1500 B.C., the High Metal Age follows immediately after, and the Protohistoric is dated to the first centuries A.D. Both surveys used informant interviews as the primary means of locating sites.

These researchers, although they could not place their sites into a tight chronological order, did distinguish between prehistoric, protohistoric, and historic sites. They concluded that the majority of the sites recorded during these surveys are dated to the prehistoric periods, although historic sites, because of the greater integrity of the high-fired pottery, should be more visible. These prehistoric sites are located on rendzina soils unsuitable for wet rice and where padi agriculture is not currently practiced. Although this pattern does not negate the possibility that some settlements of similar antiquity were engaged in wet-rice agriculture, it strongly suggests that these settlements cultivated an alternative suite of cultigens. Many of the sites are located along the middle courses of small streams, but on soils that are too porous for wet-rice agriculture. There are substantially fewer protohistoric and historic sites in the region than prehistoric sites. Like the Lam

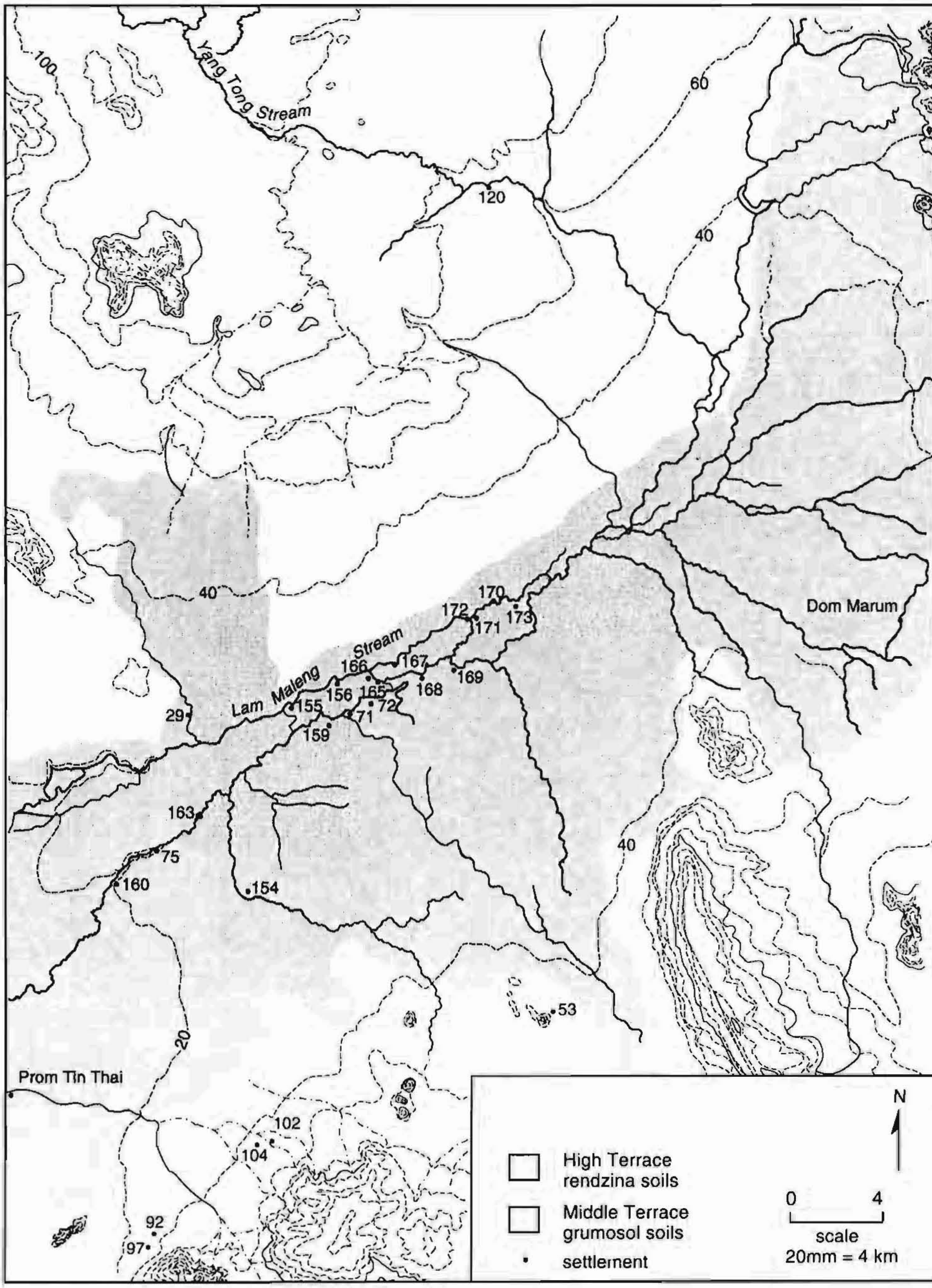

Fig. 7. Lam Maleng Survey: Dvaravati Period sites.

Maleng survey, these survey projects have identified prehistoric sites on high terraces and documented a pattern of depopulation of these same terraces by Early Historic times.

DISCUSSION: INCREASING COMPLEXITY AND AGRICULTURAL ORIGINS

Rank-Size Analysis

These survey data suggest that the Lam Maleng Valley was inhabited at least by c. 2500 B.C. by populations who lived in small settlements and whose pottery exhibited stylistic affinities with other settlements on the Eastern Marginal Plain as well as other sites in Mainland Southeast Asia. Ho (1984) has commented on the stylistic similarities in design motifs on pottery at sites such as Samrong Sen in Cambodia and Phung Nguyen in Vietnam.

In the Lam Maleng Valley, there appears to have been continued habitation of the high terrace throughout the prehistoric period, with increasing economic and political development and interaction. Analysis of regional integration of settlement systems may be approached through consideration of the relationship of sites within the system in terms of relative size. The rank-size rule suggests that in a well-integrated regional system a settlement of rank r in a descending array of settlement sizes will have a size equal to $1/r$ of the size of the largest settlement in the system (Johnson 1981 : 145). If plotted on log-log scale, this distribution yields a straight line with a slope of -1. This provides an example of complete integration, by which other examples may be evaluated.

Johnson (1981) suggests that this characteristic configuration is a function of interacting independent variables which structure site size. He notes that if a random variable "y" (here considered to be site size) is a production of a series of independent random variables (here signifying the degree of regional integration), the distribution of "y" becomes leptokurtic and skewed (which produces a log-normal line with a slope of -1) as the number of independent variables (regional integration) increases (Johnson 1981 : 151). In highly integrated systems, the size of a given settlement is a function of the sizes of the other settlements (Johnson 1981 : 152).

There are two frequently found deviations to this pattern. One is a convex distribution, in which the rank-size configuration of the samples lies above a line with a slope of -1. This indicates a condition of low integration between sites in the sample. It may suggest that the level of regional economic integration among the settlements is low. A convex distribution also occurs when the sample is composed of settlements from several settlement systems that have been pooled. Care is needed when interpreting results of this nature.

Concave distributions, sometimes called primate distributions, emerge when the largest site in a settlement system is larger than the sizes of the other sites would predict. This may occur when economic competition is minimized for the largest center. In situations of multiple settlement system interactions, this may occur when the largest site differentially interacts with centers in other settlement systems.

Examination of the rank-size distributions of sites located through the Lam Maleng survey indicates that there is an increasing approach of site-size distributions to the line representing complete integration (see Fig. 8). This configura-

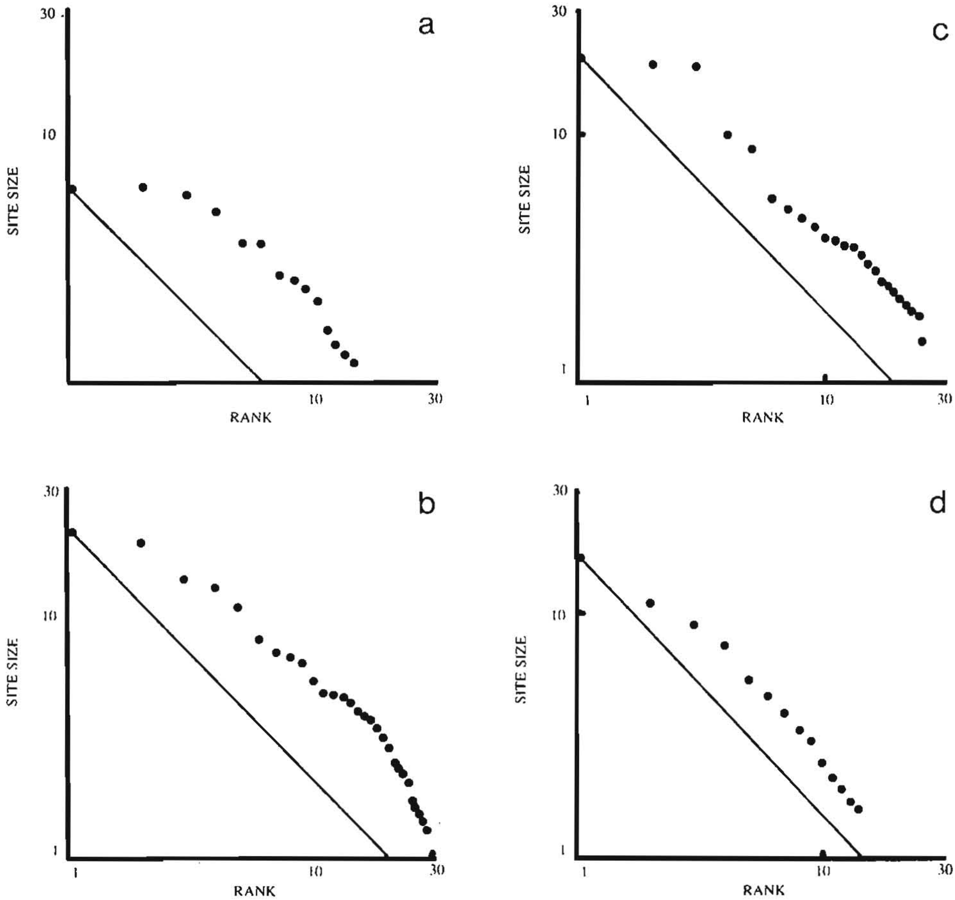

Fig. 8. Rank-size distribution of sites from the Lam Maleng Valley. (*a*) Early Period sites (*b*) Middle Period sites (*c*) Protohistoric sites (*d*) Early Historic sites

tion suggests that there is increasing regional integration through time. The Dvaravati sites are not included in this examination, as they are clearly components in a larger settlement system and thus do not constitute a representative sample.

Catchment Analysis

One way to examine relationships between natural resources and settlement location is through catchment analysis. Catchment analysis is predicated on the simple assumption that, within limits, there is a predictable relationship between placement and size of a settlement and the carrying capacity of the physical environment within a certain distance of that site, its catchment. The delineation of this relationship can yield data about the seasonal round, subsistence economy, and exploited resources of foraging populations (Jochim 1976). The method can be used to evaluate the adaptations of agriculturalists as well as foragers; a variation on this method has also been used to identify tributary economies in complex chiefdoms and early states (Steponaitis 1981).

Catchment analysis can be approached in at least two ways. One way is to assess the resources within a given area, the catchment of the known site, to establish the carrying capacity and exploitation schedule of people utilizing resources there (Jochim 1976). Another way seeks to identify the resources used by comparing the proportions of resources in the catchment area of each site to the proportions of the delineated region as a whole (Zarkey 1976). This method compares the percentages of the targeted resource in the catchment of each site to the proportion of that resource within the study area as a whole. If the sites are randomly placed within the study area, the occurrence of a resource within the total catchment areas of the sites should be proportional to the occurrence of the resource in the region as a whole. If settlements are situated to take advantage of a particular resource, there should be a higher proportion of this resource in catchments than in the region as a whole. Essentially, this method makes it possible to identify whether sites are placed randomly or nonrandomly with respect to a resource, hypotheses that can be evaluated with a simple chi-square test.

Models of settlement distribution based on current assumptions about subsistence systems in interior Mainland Southeast Asia predict that there should be avoidance of high-terrace soils, which are unsuitable for wet rice, and preference for low and middle terraces with clayey, water-retentive soils.

Catchment analysis, comparing the percentage of sites located with access to various types of soils to the percentage of those soils in the survey area, was used to examine the relationship between resources and site location (Table 2). Comparative work by Naroll (1962) suggests that agriculturalists limit the time they spend traveling to and from cultivated plots. This time translates into an average of 1–2 km. A catchment radius of 1 km was used in this study. With few exceptions, only one soil type was represented in a 1 km radius area of each site, and is reported as such.

Hypotheses about settlement patterns predicated upon locational preference with reference to soil types may be tested with the results of the Lam Maleng

Table 2. Chi-Square Analyses of Settlement Location for Each Time Period in the Lam Maleng Valley with Respect to Terrace Type

	TIME PERIOD							
	PREHISTORIC			PROTOHISTORIC		DVARAVATI		
	f^1	$f^{adj.}$	f^2	f^1	f^2	f^1	$f^{adj.}$	f^2
Middle Terrace								
p = .33	26	26.5	38	6	7	19	18.5	8
High Terrace								
q = .66	78	78.5	66	13	12	6	6.5	17
N =	104			19		25		
$X2^a$ =	2.6^b			0.026^b		19.29^c		

[a] Prehistoric and Dvaravati data examined with G test for two classes of data and adjusted with Yates correction for small sample sizes. Protohistoric data examined through computation of binomial probabilities (Sokal and Rohlf 1969:563).
[b] Not significant.
[c] Significant at 0.001 level.

Valley survey. If sites were placed to gain access to soils suitable for wet-rice agriculture, we would expect to see an association between middle-terrace soils and site placement. The distribution of sites dated to the long Prehistoric Period, the Protohistoric Period, and the Dvaravati Period with reference to middle and high geomorphological terraces was assessed with a goodness-of-fit test (see Table 2). Each time period was assessed independently. The prehistoric sample was composed both of sites that were dated to the Early, Middle, and Late Prehistoric periods and of those which could not be assigned to a specific prehistoric period.

Results of the goodness-of-fit test demonstrate that there is no significant association between middle-terrace soils and locations of Prehistoric Period sites. The proportion of settlements in each location did not differ significantly from that predicted on the basis of the proportion of terrace types in the survey area. This indicates that there was no locational preference for terrace type, either middle or high, and no demonstrated preference for soils appropriate for padi agriculture.

Grouping sites from the long Prehistoric Period into one sample may obscure shifts in locational preference through time. To examine this proposition, sites that could be assigned to a specific time period were examined (see Table 3). Independent goodness-of-fit tests for sites from the Early, Middle, and Late Prehistoric time periods indicate that there is a nonrandom association between settlement location and terrace type. The association is not with middle terraces, however, but with high terraces. This preference for high-terrace locations is exhibited in all three prehistoric time periods.

A goodness-of-fit test for the Protohistoric Period sites indicates that this pattern between terrace type and location is not present. The distribution did not differ significantly from that predicted on the basis of the proportions of terrace types.

A goodness-of-fit test for the sample of Dvaravati sites, however, indicates that there is a significant association between middle terraces and sites dated to this time period. This supports evidence from other sources demonstrating that wet rice was a significant component of the Dvaravati economy.

TABLE 3. CHI-SQUARE ANALYSIS OF SETTLEMENT LOCATION IN THE LAM MALENG VALLEY WITH RESPECT TO TERRACE TYPE FOR DATED PREHISTORIC SITES

	TIME PERIOD							
	EARLY		MIDDLE			LATE		
	f^1	f^2	f^1	$f^{adj.}$	f^2	f^1	$f^{adj.}$	f^2
Middle Terrace								
p = .33	3	7	10	10.5	16	6	6.5	14
High Terrace								
q = .66	17	13	39	39.5	33	35	34.5	27
N =	20		49			41		
x^{2a} =	2.97[b]		3.0[b]			5.54[c]		

[a] Middle and Late Period data examined with G test for two classes of data and adjusted with Yates correction for small sample sizes. Early Period data examined through computation of binomial probabilities (Sokal and Rohlf 1969:563).
[b] Significant at 0.01 level.
[c] Significant at 0.001 level.

These survey results indicate that prehistoric sites were predominantly located on high terraces, on soils not suited for wet-rice agriculture. Clear preference for middle-terrace soils does not occur until the Early Historic Period.

Settlement Characteristics and the Case for Dryland Agricultural Economies

The data collected during the course of the survey suggest that the prehistoric settlements located on the upper terraces were permanent. Site sizes and density of artifacts on the surfaces of these sites, as high as 100 grams per m^2, suggest that the occupational history of these sites was of some duration. This implies that the subsistence economy was reliable and stable.

Sites were located along the margins of small streams, as has been described for settlements thought to have been involved in wet-rice agriculture in northeastern Thailand (Higham 1989*a*: 130). At present, however, the streams in the Lam Maleng Valley run through incised streambeds. While down-cutting may have been relatively recent, it is not likely that the natural flooding that has been described as a key component of early agricultural systems (White 1984) would have occurred in the upper reaches of the watershed.

The area is currently devoted to dry farming and may have been in the past as well. If dryland agriculture was a significant component of the prehistoric economy, we might expect to see an association between site location and soil type. Independent goodness-of-fit tests for the prehistoric and protohistoric samples indicate that there is a clear preference for Takhli soils (see Table 4). This affinity for Takhli soils suggests that the economic base of the settlement was related to a resource associated with this soil type, or with the agricultural potential of the soil.

This evidence suggests that the inhabitants of prehistoric soils on the high terraces were engaged in some form of agriculture that did not include cultivation of wet rice. In the recent past, dry rice, millet, and root crops were important com-

TABLE 4. CHI-SQUARE ANALYSES OF PREHISTORIC AND PROTOHISTORIC PERIOD SETTLEMENT LOCATION OF HIGH TERRACES OF THE LAM MALENG VALLEY WITH RESPECT TO SOIL TYPES

	TIME PERIOD									
	EARLY	MIDDLE			LATE			PROTO-HISTORIC		
	f^1	f^2	f^1	$f^{adj.}$	f^2	f^1	$f^{adj.}$	f^2	f^1	f^2
Takhli soil type										
p = .58	15	10	36	35.5	23	27	26.5	20	13	8
Other soil types[a]										
q = .42	2	7	3	3.5	16	8	8.5	15	0	6
N =	17		39			35			13	
X^{2b} =	6.3		18.84			13.7			9.4	

[a] Other high-terrace soil types were collapsed into one category to avoid empty cells.
[b] Middle and Late Period data examined with G test for two classes of data and adjusted with Yates correction for small sample sizes. Early and Protohistoric Period data examined through computation of binomial probabilities (Sokal and Rohlf 1969:563). All tests significant at 0.001 level.

ponents of subsistence economies in Southeast Asia (Spencer 1963). They may have been important elements in the prehistoric diet as well. Information from ethnographically known groups that incorporated these cultigens into the subsistence economy emphasizes shifting agriculture as a common agricultural practice. Depending on population levels and soil fertility, however, shifting agriculture need not entail periodic settlement relocation. Permanent settlements may have been maintained in the Lam Maleng Valley, especially on the fertile soils of the high terraces.

Questions of occupational duration bearing on agricultural practices cannot be answered with survey data. However, additional information about settlement longevity in this region comes from the site of Kok Charoen. This site is located about 50 km to the northeast of the Lam Maleng Valley in the Pa Sak River Valley in Petchabun Province. A total of 400 m^2 was excavated between 1966 and 1970 by the Thai–British Project. Unfortunately, our knowledge of the results of their efforts is confined to preliminary site reports (Loofs-Wissowa 1970; Loofs-Wissowa and Watson 1970; Watson and Loofs-Wissowa 1967) and a study of the burials (Ho 1984). The most extensive information about the site comes from Ho's (1984) analysis.

The excavations have produced evidence for a relatively stable occupation of the site for some period of time (Ho 1984). The presence of a cemetery that appears to be spatially segregated suggests the presence of permanent buildings which have restricted burial placement. In addition, large quantities of domestic pottery were recovered, also suggesting permanent habitation.

Kok Charoen is located at the confluence of two small tributaries to the Pa Sak River and dates to approximately 1500 B.C. Currently, agriculture in the region is based on dryland farming, although irrigated padi agriculture is practiced in the main river valley. It is probable that the area was unsuited to wet rice in the past. Thus, as with sites on the upper terraces of the Lam Maleng Valley, the environmental location of Kok Charoen suggests that the subsistence economy was based on resources other than wet rice. Further, the data from excavations there indicate that this economy probably did not involve frequent relocation of sites.

If it may be argued that settlements in this area were permanent or semipermanent, and that wet-rice cultivation was not generally possible, then alternative cultigens may have been grown. Millet, dry rice, and root crops are likely possibilities.

Millets consist of five genera in the tribe Panaceae; like other cereal grains, millets are grasses. In Asia, the most common domestic species are *Panicum miliaceum* and *Seterica italica,* foxtail millet. The wild ancestor of foxtail millet, *Seterica viridis,* has the widest distribution of any Asian annual cereal. It ranges from India east and from northern Asia south to Southeast Asia and out into the island archipelago.

Millet cultivation is largely incompatible with padi agriculture. The plant prefers loose soil with good drainage and can tolerate short-term stress from lack of water. In Southeast Asia, millet requires less energy to grow than either padi or dry rice. It needs only one weeding per agricultural cycle. It is less demanding of soils than dry rice and can be grown on the same plot of ground for longer periods of time (Fogg 1978 : 40).

Domestic foxtail millet has as wide a distribution as its wild ancestor. It was extensively grown in the loess regions of northern China by 8000 B.C. (Crawford

1992:24). Austronesian-speaking groups in Taiwan depended on millet for at least 50 percent of their dietary needs (Fogg 1978:36). Dentan (1971) reported that the Semoi Senai in highland Malaya grew millet along with maize and dry rice. Bodner (1986) found that the Bontoc in northern Luzon, Philippines, planted millet as a swidden crop.

Because it is currently grown most extensively in North China, this region is cited as the origin of domesticated millet (Li 1970). It may have been part of the Southeast Asian economy at an early period as well. A Proto-Austronesian term for millet has been reconstructed (Blust 1976), and Bellwood argues that millet was part of the agricultural repertoire of the Austronesian expansion, thought to have taken place between 4000 and 2000 B.C. (Bellwood 1980). Fogg proposes that millet was a Southeast Asian domesticate. He characterizes millet farming in northern China as difficult, requiring labor-intensive and sophisticated techniques to protect plants from frost and drought (Fogg 1978:20). The more equitable climate of Southeast Asia, Fogg argues, would have been more amenable to millet production by simple means.

Ethnographic evidence shows that millet is an important staple crop in traditional agricultural systems and may have been replaced by wet rice and, in Island Southeast Asia, by maize, at a later time. Linguistic reconstruction indicates that the presence of this domesticate has some time-depth in Southeast Asia; this region may have been an origin of domesticated millet. Thus, millet may have been available to prehistoric inhabitants of the Lam Maleng Valley. African millets are successfully grown on high terraces in the region today; the available evidence suggests that it was possible to grow millet during prehistoric times as well.

Another crop that may have been grown is dry rice. Dry rice, *Oriza sativa*, is genetically indistinguishable from wet rice. Unlike its aquatic counterpart, however, dry rice tolerates more arid conditions and can be planted using the same methods as other cereal grains. Dry rice was probably derived from wet rice, but the circumstances of the development of dryland varieties are unknown. No morphological features have been recognized to distinguish either seeds or stems of dry rice from wet rice. Thus, no dry rice has been conclusively identified from archaeological sites: rice remains that have been recovered have been assumed to be from wet rice.

Ethnographic studies indicate that dry rice was an important component of traditional agricultural systems in Southeast Asia. Izikowitz observed Lamet growing dry rice in upland Laos (Izikowitz 1951). Shan farmers living in Maehongsong Province, Thailand, grow dry rice to supplement limited padi fields (Durrenberger 1978). Hanks noted that pioneers in the Rangsit region of the Bangkok Plain brought swidden-planting practices with them from their upland homes (Hanks 1972). Given the widespread cultivation of this grain among agriculturalists, and the antiquity of padi varieties, it is possible that dry rice was grown on the high terraces of the Lam Maleng Valley.

The category of "tubers" subsumes a number of unrelated taxa, including yams and wild and domesticated aroids. White (1984:31) has identified at least five species of wild yams from Northeast Thailand. Bodner (1986) noted that at least three species were grown by the Bontok of the Philippines, along with sweet potatoes and taro. Fogg (1978) found that the indigenous people in Taiwan depended on tubers for up to half of the carbohydrates in their diet. Southeast

Asia was undoubtedly a source of tubers grown throughout Oceania in prehistoric times, but it is unclear whether Island or Mainland Southeast Asia was the ultimate primary source of these species.

Ethnographic information from Mainland Southeast Asia indicates that tubers may have been an important supplement but did not replace grain cultivation as a source of calories. White (1984) argues that yams may have been a critically important component of the diet during early stages of wet-rice domestication. These species may have been maintained in the agricultural repertoire as a security measure against grain-crop failure. Characteristics of vegetative subsurface propagation would have promoted a different response to environmental perturbations such as drought, insect infestations, and high winds and rain. Thus, cultivation of tubers may have been important as a dietary supplement and insurance against hunger in case of grain-crop failure.

At present, no tubers have been recovered from archaeological sites in Southeast Asia. Arguments for their presence in the prehistoric diet are largely based on ethnographic analogy, much in the same way as arguments for the prehistoric importance of wet rice. The settlement pattern data from the Lam Maleng Valley, however, suggest that wet-rice cultivation was not possible, and therefore that other cultigens must be considered. Millet, dry rice, and tubers are significant components of a diverse array of cultigens in agricultural systems known ethnographically, and may have been equally significant in prehistoric contexts as well.

CONCLUSIONS

Intensive survey in a 60 km^2 area on the eastern Marginal Plain of central Thailand has produced a sample of sites from which a settlement pattern has been drawn. This pattern indicates that the earliest villages in the Lam Maleng Valley were concentrated on upper terraces, which provided access to soils suitable for dry farming. There does not appear to be an emphasis on location of sites adjacent to land appropriate for padi cultivation until after 500 B.C., and possibly as late as A.D. 500. The majority of the identified Dvaravati sites were located on middle terraces. A similar distribution of sites was identified by two other surveys conducted in the same region.

There is evidence to suggest that by the Late Prehistoric Period iron technology was readily available, as a number of sites on the upper terraces yielded iron slag. At some time after the appearance of iron, the upper terraces were abandoned. It is difficult, however, to identify the period of abandonment based on the provisional chronology developed from surface collections. Access to iron technology is associated with agricultural intensification and increasing social complexity in at least one model for the emergence of social complexity in Mainland Southeast Asia (Higham 1989*a*: 235). If abandonment of the upper terraces can be shown to have occurred shortly after the appearance of iron technology, these data may support a model that associates the emergence of complex polities with agricultural intensification.

The settlement data may also be interpreted to indicate that cultivation of wet rice was not a major agricultural focus until as late as the Early Historic Period, c. A.D. 500. The Early Historic Period in the Lam Maleng Valley is represented by Dvaravati sites, which in central Thailand are identified as being part of a complex polity. It is not inconceivable that administrative activities in the polity were underwritten by surpluses of agricultural produce. There may have been recruitment of labor to produce this surplus. Reorganization of supporting hinterlands and territorial expansion are common features of the emergence of complex polities, and we might expect to see these processes in the development of the Dvaravati Kingdom.

This settlement pattern and the cultural history it implies may be unique to the Eastern Marginal Plain. The Lopburi Grumosol is relatively fertile, but it is not suitable for padi cultivation and the rainfall pattern is relatively unpredictable. These environmental characteristics may have favored dry farming over wet-rice agriculture. If dry-field farming was practiced, the cultigens must have already been in place in the agricultural repertoire, as there is no evidence to suggest that there was in situ domestication of plants. This might mean that dry-field crops were present in other areas in Mainland Southeast Asia, and yet there is little evidence to support agricultural alternatives to wet rice. This may be partly a function of research design, particularly survey methods.

A comparison of the results of survey projects conducted in Southeast Asia in the last 15 years suggests that there is a noticeable correlation between survey methods and survey results. Overall, density of sites recovered is greater with systematic surface survey than with informant interviews or examination of aerial photos alone. Although it is not possible to verify this without independent survey of the same areas, I suggest that these methods focus on the recovery of large mounded sites, and of sites located near present-day villages. Small, ephemeral sites and sites situated away from extant villages may tend to be underrepresented in samples generated by these survey methods. Because current habitations are associated with soils suitable for wet-rice agriculture, archaeological sites recovered by these techniques should also exhibit the same correlations between location and soil type. Settlements situated near soils not appropriate for wet rice will be underrepresented in the resulting samples. The samples that have been generated may only address a restricted portion of the total settlement pattern, identifying late rather than early sites. Although it is likely that rice was cultivated during the Early Prehistoric Period in Northeast Thailand, it is possible that other suites of cultigens were also grown there.

The prehistoric-early historic settlement pattern characteristic of the Lam Maleng Valley might be found in other regions in Mainland Southeast Asia but have simply not been detected through currently used survey methods. Results of the Phimai and the Lam Maleng survey projects have produced more representative samples. These results suggest that the subsistence economy may have been more diverse than has previously been supposed. If, as seems likely, survey in other areas appropriate for dry-farming produces settlement patterns of some antiquity, these results have the potential to overturn current views of the development of the Southeast Asian economy. Further, if it can be demonstrated that a shift to an energy-intensive agricultural system of wet-rice agriculture occurred late in the protohistoric sequence in the Lam Maleng Valley, and coincided with the emergence of political complexity in the region, then political and economic rather than ecological explanations should be sought for this agricultural reorganization.

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ABSTRACT

Recent research on the eastern margins of the Bangkok Plain in central Thailand has identified a series of prehistoric sites that do not fit a pattern of reliance on wet rice agriculture. A systematic settlement survey in Lopburi Province has identified habitation dating from the third millennium B.C. to the first millennium A.D. on a fan-terrace complex adjacent to the Central Plain. The survey focused on the middle- and high-terrace areas of the Lam Maleng Stream Valley. Results indicate that a significant number of the prehistoric sites were located on high terraces whose soil characteristics did not encourage wet-rice cultivation, suggesting that these settlements did not rely on wet rice for subsistence. Migration to middle-terrace soils suitable for wet rice did not occur until after the beginning of the present era, further indicating that a shift to wet-rice cultivation occurred relatively late in the occupation of the area.

A pattern of prehistoric settlement location excluding ready access to rice-growing soils has not been reported for Mainland Southeast Asia, possibly because of the unusual features of soil and climate in the eastern Marginal Plains. Agricultural strategies in prehistoric Mainland Southeast Asia may have been more diverse than generally thought. Assumptions about the importance of wet rice in the prehistoric economies of Southeast Asian societies may also have structured research strategies, especially survey methods, in ways that have not produced representative samples of sites. Results from the Lam Maleng Valley survey suggest that dryland farming may have provided a viable economic base prehistorically. KEYWORDS: locational analysis, wet rice agriculture, central Thailand.

Appendix 1. Sites Located During 1989–1990 Survey Season in the Lam Maleng Valley, Lopburi Province, Thailand

Site No.	Site Name	Latitude	Longitude	Subsize Area (in Hectares)[a]		Period[b]	Soil[c]
4	Ban Chon Bon	15°10′5″	100°44′23″	KC	10.00	MP-LP	TK
5		15°13′24″	100°45′37″	YT	13.75	MP	TK
6	Ban Don Charoen	15°14′5″	100°42′18″	YT	5.49	LP	TK
7	Shim Onim Farm	15°14′8″	100°45′52″	YT	2.60	EP	TK
11	Wat Chon Takien	15°14′42″	100°45′48″	YT	3.31	MP-LP	TK
12	Ban Bo Ta Krang	15°15′26″	100°46′18″	YT	2.82	MP	TK
17	Ban Chon Gaeow	15°10′06″	100°41′20″	KC	1.32	MP	TK
18	Ban Sap Dipli	15°13′18″	100°44′38″	YT	12.04	LP	TK
20	Bo Ta Sima	15°14′00″	100°43′03″	YT	3.62	EP-MP	TK
21	Ban Bo Yang	15°14′49″	100°40′41″	YT	—	MP	BC
22	Nont Sroi Plu Farm	15°13′19″	100°45′55″	YT	4.25	MP-LP	TK
23	Thongsook Pipitthong	15°13′37″	100°45′45″	YT	1.93	MP	TK
24	Charoen Kluaydi Farm	15°14′13″	100°46′02″	YT	6.36	EP-LP	TK
25	Non Pa Wai	14°58′08″	100°40′47″	HP	4.50	EP-MP	TK
25-2	Non Pa Wai(outlier)	14°58′08″	100°40′47″	HP	—	EP	TK
29	Ban Wang Jan Noey	15°05′20″	100°40′20″	LM	12.08	DV-KH	TK-WT
35	Non Kok Wa	14°58′05″	100°40′58″	HP	1.00	MP-LP	TK
45	Non Mak La	14°57′41″	100°40′55″	HP	20.00	MP-LP	TK
46	Ban Phu Nam Thip	15°09′42″	100°42′47″	KC	1.30	LP	TK
47	Ban Chon Saradet	15°10′34″	100°40′35″	KC	—	MP-LP	TK
48	Ban Noem Som Kop	15°02′31″	100°39′00″	CK	3.88	LP	TR
49				LM	—	PP	
52	Kok Cham	15°02′40″	100°40′43″	LM		AY	LBLP
53		14°15′00″	100°55′00″	—	10.40	PH-DV	TK-LP
54		15°09′30″	100°41′32″	KC	0.15	EP	TK
55		15°08′57″	100°42′18″	KC	13.60	MP-LP	LBLP
57		15°10′00″	100°41′50″	KC		MP-LP	TK
58		15°10′00″	100°40′15″	CK	1.12	MP-LP	TK
59		15°10′00″	100°40′15″	CK	0.32	MP	TK
60		15°09′52″	100°40′33″	CK	0.24	MP	TK
61		15°09′48″	100°40′28″	CK	0.21	PP	TK
63		15°09′44″	100°40′27″	CK	0.36	PP	TK
64		14°09′14″	100°40′01″	CK	0.49	LP	TR
65		14°09′13″	100°39′59″	CK	0.40	MP	TR
66		15°09′05″	100°40′03″	CK	0.76	PP	TR
67		15°08′47″	100°40′08″	CK	0.36	MP	TR
68		15°08′48″	100°40′52″	CK	0.07	MP	TR
69		15°08′28″	100°41′23″	CK	0.39	MP	LP
70		15°08′36″	100°40′51″	CK	0.03	PP	TR
71		14°05′30″	100°42′59″	LM	0.15	DV	KS
72	Kok Chao Phraya	14°05′39″	100°43′10″	LM	0.35	DV	KS
74	Non Nom Eom	15°03′29″	100°40′11″	LM	1.10	PP	TR
75		15°03′20″	100°39′50″	LM	0.64	DV	TR
77		15°11′47″	100°41′12″	—	0.74	AY	BC-TK
78		15°12′13″	100°40′42″	—	0.07	AY	
80-1	Huai Pong Valley	14°59′08″	100°40′33″	HP	4.68	EP-MP	TK
80-2		14°59′08″	100°40′33″	HP	4.08	AY	TK
81	Nil Kam Haeng	14°57′10″	100°39′27″	HP	2.88	LP-?	TT
82	Ban Khao Phuu Kaa	14°57′32″	100°39′28″	HP	2.49	LP	TT
83		15°00′00″	100°41′13″	HP	2.30	AY	LBLP
85	Silapakorn Site	15°10′15″	100°43′23″	KC	5.40	EP	TK
86		15°00′00″	100°40′05″	HP	0.02	LP	TT
87		14°57′02″	100°40′08″	HP	1.27	PH	TK

(*Continues*)

SITE NO.	SITE NAME	LATITUDE	LONGITUDE	SUBSIZE AREA (IN HECTARES)[a]		PERIOD[b]	SOIL[c]
89		14°58′58″	100°39′55″	HP	16.80	AY	TT-LB
90		14°58′19″	100°40′27″	HP	0.13	PP	LBLP
91		14°58′18″	100°40′32″	HP	0.56	PP	LBLP
92		14°57′37″	100°39′52″	HP	1.00	DV	TT
93	Ban Nong Hoi	15°02′00″	100°39′50″	LM	—	PH	TR
94		15°01′19″	100°41′10″	HP	0.05	MP	TT
96		14°57′50″	100°39′50″	HP	7.20	PH	TK
97		14°57′18″	100°39′45″	HP	3.31	PH-DV	TK
98		14°58′23″	100°41′00″	HP	1.04	PP	TK-LB
99-1		14°59′05″	100°41′05″	HP	4.44	MP	TT
99-2		14°59′13″	100°40′55″	HP	1.48	LP	LBLP
100		14°58′54″	100°40′32″	HP	0.48	AY	LBLP
101		14°58′45″	100°40′25″	HP	0.48	AY	LBLP
102		14°58′55″	100°41′45″	HP	1.96	PH-DV	LBLP
103		14°58′45″	100°40′25″	HP	0.68	AY	LBLP
104		14°58′49″	100°41′37″	HP	0.43	PH-DV	TK-LB
105	Ban Nong Krathum	14°59′37″	100°45′50″	HP	0.91	EP-MP	LBLP
106		15°13′31″	100°45′48″	YT	1.62	MP	TK
107		15°14′52″	100°46′06″	YT	4.68	PP	TK
108		15°15′50″	100°45′50″	YT	3.88	MP-LP	TK
109		15°13′04″	100°46′08″	YT	5.12	LP	TK
110		15°13′05″	100°45′56″	YT	3.80	PP	TK
111		15°12′50″	100°46′37″	Yr	6.52	MP	TK
112		15°12′47″	100°46′32″	YT	2.43	AY	LPHP
114		15°12′35″	100°47′05″	YT	3.04	LP	LBHP
115		15°12′52″	100°47′00″	YT	1.04	MP	LBHP
116		15°13′00″	100°46′32″	YT	2.24	MP	LBHP
117		15°13′41″	100°45′27″	YT	2.70	PP	TK
118		15°13′47″	100°44′42″	YT	3.20	PH	TK
119		15°13′40″	100°44′30″	YT	7.06	PH	TK
120		15°13′43″	100°44′35″	YT	5.58	PH-DV	TK
121		15°13′50″	100°44′07″	YT	2.12	EP	TK
122		15°13′27″	100°44′22″	YT	5.08	MP-LP	TK
123		15°13′32″	100°44′36″	YT	1.20	PP	TK
124		15°13′33″	100°44′41″	YT	2.64	EP-LP	TK
125		15°13′57″	100°44′03″	YT	1.61	PP	TK
126		15°14′04″	100°43′52″	YT	0.71	LP	TK
127		15°13′50″	100°43′45″	YT	2.08	MP-LP	TK
128		15°13′40″	100°44′13″	YT	0.61	LP	WH
129	Ban Bo Ta Pang	15°14′00″	100°42′55″	YT	0.82	PH	TK
130		15°14′00″	100°43′24″	YT	2.00	MP	TK
131	Ban Chon Lek Fai	15°13′20″	100°47′03″	YT	2.40	EP-LP	LBHP
132		15°09′21″	100°41′10″	KC	1.28	PP	TK
133		15°09′21″	100°41′10″	KC	1.08	LP	TK
134		15°09′53″	100°40′40″	CK	0.65	EP	TK
135		15°09′50″	100°40′40″	CK	0.83	PP	TK
136		15°09′40″	100°40′40″	CK	2.48	MP-PH	TK
137		15°09′35″	100°40′40″	CK	1.72	MP	TK
138		14°09′13″	100°39′59″	CK	0.86	EP-MP	TK
139		15°10′10″	100°39′58″	CK	2.00	MP-LP	TK
140		15°10′18″	100°39′56″	CK	0.60	LP-PH	TK
141		15°10′42″	100°40′18″	CK	1.80	PH	TK
143		15°10′47″	100°40′25″	CK	1.72	MP	TK

(*Continues*)

APPENDIX I. (*Continued*)

SITE NO.	SITE NAME	LATITUDE	LONGITUDE	SUBSIZE AREA (IN HECTARES)[a]		PERIOD[b]	SOIL[c]
144		15°10′05″	100°40′10″	CK	4.32	PP	TK
145	Ban Nong Khaem 1	15°08′35″	100°41′05″	KC	3.76	MP-LP	TR-LB
146	Ban Nong Khaem 2	15°08′38″	100°41′18″	KC	0.52	MP	TR-LB
148	Ban Chon Saradet South	15°10′36″	100°40′18″	CK	0.33	EP	TK
149		15°10′17″	100°40′04″	CK	1.76	PP	TK
150-1		15°06′12″	100°39′52″	LM	18.25	MP-LP	LBLP
150-2		15°06′12″	100°39′52″	LM	4.50	PH	LBLP
151		15°06′12″	100°39′52″	LM	1.52	MP	LBLP
152		15°06′37″	100°39′29″	LM	0.70	EP	LBLP
153				LM	—	PH	LBLP
154		15°02′40″	100°40′29″	LM	2.16	DV	LBLP
155		15°05′36″	100°42′02″	LM	1.44	PH-DV	TR
156		15°05′50″	100°42′47″	LM	5.08	DV	WT
157		15°05′12″	100°42′02″	LM	1.40	PP	TR
158		15°04′40″	100°41′16″	LM	3.60	EP-LP	TR
159				LM	—	DV	
160		15°02′44″	100°39′06″	LM	3.1	DV	TR
161		15°03′16″	100°39′24″	LM	8.68	LP-PH	TR
162		15°02′45″	100°39′14″	LM	0.62	PP	TR
163		15°03′45″	100°40′33″	LM	2.00	DV	TR
164		15°10′12″	100°44′28″	LM	7.40	MP	TK
165		15°06′01″	100°43′11″	LM	0.60	DV	WT
166		15°06′05″	100°43′15″	LM	13.60	DV	WT
167		15°06′20″	100°43′46″	LM	2.56	DV	WT
168		15°06′07″	100°44′02″	LM	1.02	DV	WT
169		15°06′08″	100°44′42″	LM	3.32	DV	WT
170		15°07′13″	100°45′25″	LM	5.68	DV	WT
171		15°07′08″	100°45′01″	LM	13.60	DV	WT
172		15°07′00″	100°44′59″	LM	13.20	EP-DV	WT
173		15°07′11″	100°45′45″	LM	0.44	DV	WT
174		15°07′24″	100°45′44″	LM	—	PP	WT
175		15°10′08″	100°42′21″	KC	1.68	EP	TK
176		15°10′08″	100°42′26″	KC	1.40	LP	TK
177-1		15°10′15″	100°42′48″	KC	2.48	EP-PH	TK
177-2		15°10′15″	100°42′48″	KC	3.12	MP	TK
177-3		15°10′15″	100°42′48″	KC	1.48	LP-PH	TK
177-4		15°10′15″	100°42′48″	KC	3.08	EP-PH	TK
178		15°10′34″	100°44′07″	KC	2.36	PP	TK
179		15°10′21″	100°44′09″	KC	4.80	LP	TK
180		15°10′19″	100°43′04″	KC	0.26	AY	TK
181		15°10′19″	100°43′04″	KC	0.40	LP	TK
182		15°10′30″	100°44′13″	KC	3.08	MP	TK

[a] YT = Yang Tong Valley
CK = Chon Khut Plain
KC = Khao Chakchan Ridge
LM = Lam Maleng Valley
HP = Huai Pong Stream Valley

[b] EP = Early Prehistoric
MP = Middle Prehistoric
LP = Late Prehistoric
PH = Protohistoric
DV = Dvaravati
KH = Khmer
AY = Ayuttaya

[c] HIGH-TERRACE SOILS:
LBHP = Lopburi High Phase
PC = Pak Chong
TK = Takhli
WH = Wang Hai
MIDDLE-TERRACE SOILS:
BC = Bak Chong
CK = Chong Kae
KS = Kok Samrong
LBHP = Lopburi Low Phase
TR = Tha Rhua
TT = Tha Tako
WT = Wattana